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ABSTRACT

Environmental tobacco smoke (ETS) is one of the most widespread and harmful indoor pollutants. This document offers guidelines for controlling ETS in schools. The harmful effects of passive smoke and the Maryland policy regarding smoking in public places are first described. Strategies to control exposure to ETS are outlined, with consideration of ventilation standards and air replacement sources. Architectural and maintenance considerations and other means of contaminant removal are discussed. Three figures are included. (LMI)

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GUIDELINES FOR CONTROLLING ENVIRONMENTAL TOBACCO SMOKE IN SCHOOLS

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Indoor Air Quality

Americans spend about 90 percent of their time indoors. Thus the levels of indoor air contaminants are important in determining total exposure to air pollutants.

Indoor air quality problems are usually attributed to the proliferation of sources of indoor air contaminants combined with widespread energy conservation practices, such as reducing windows and door openings and sealing the building envelope more tightly.

In many buildings, outside air quantities introduced into the building have been minimized and operating times for the mechanical systems reduced. Also, the maintenance of mechanical systems is often deficient.

As a result, contaminants such as particles and gases tend to be retained in occupied spaces for longer periods of time and in higher concentrations.

Environmental Tobacco Smoke

Environmental tobacco smoke (ETS) is one of the most widespread and harmful of the pollutants found indoors. In 1986, the Surgeon General's report entitled, *The Health Consequences of Involuntary Smoking*, pointed out that tobacco smoke can be a significant source of atmospheric pollution in enclosed areas and that "...indoor air pollution from tobacco smoke is pandemic." It is estimated that about 467,000 tons of tobacco are burned indoors each year.

Cigarette smoke contains more than 4700 chemical compounds, including: carbon monoxide, nicotine, carcinogenic tars, sulfur dioxide, ammonia, nitrogen oxides, vinyl chloride, hydrogen cyanide, radio-nuclides and arsenic. There are 43 carcinogenic compounds that have been identified in tobacco smoke.

Health Effects of Passive Smoking

Of the number of nonsmokers dying from lung cancer each year, the surgeon general attributes a substantial number to passive smoking. Several studies have also linked involuntary smoking with heart disease.

The children of parents who smoke, when compared to the children of nonsmokers, have an increased frequency of a variety of acute respiratory illnesses and infections.

In 1986 the surgeon general concluded that adults should protect the health of children by not exposing them to ETS.

Irritating Effects of Passive Smoke

The main effects of the irritants present in ETS occur in the conjunctiva of the eyes and the mucous membranes of the nose, throat, and upper respiratory tract. Allergic persons report wheezing, sneezing, and nausea. Particularly acute symptoms may be found in infants, children, persons with cardiovascular or respiratory disease, and wearers of contact lenses.

Contamination and odors are immediately created by such elements in tobacco smoke as ammonia and pyridine. These odors tend to linger.

Policies Restricting Smoking in Public Places and the Workplace

Beginning with the 1970s, an increasing number of public and private sector institutions adopted policies to protect individuals from exposure to environmental tobacco smoke.

Smoking restrictions have occurred at federal, state, and local government levels. All but 13 states have enacted laws regulating smoking in public or private workplaces.

The State of Wisconsin, for instance, has prohibited smoking on school premises since September 1st, 1990. Local governments have enacted smoking ordinances at an increasing rate since 1980 and at least 297 cities and counties restrict workplace smoking. Approximately 35 percent of businesses have adopted smoking policies.

In Maryland schools, the predominant policy is to allow staff smoking in designated areas. Many designated smoking areas are the only lounge areas available to nonsmoking staff. Often the ventilation system for the lounge is part of the same system serving a portion of or the entire building.

Control

ETS can be totally removed from the indoor air only by removing the source. Separating smokers and nonsmokers in the same room may reduce, but will not eliminate, nonsmokers' exposure to tobacco smoke. Since there is no established threshold for exposure to ETS, the EPA recommends that exposure should be minimized wherever possible.

The most effective way to minimize exposure is to restrict smoking to areas that are separately ventilated and directly exhausted to the outside, or by eliminating smoking in the school altogether.

Ideally, the smoking lounge can control the exposure to ETS by several means.

1. By creating an isolated area, smoking can occur without risk or annoyance to others.

2. By supplying air free of ETS, the buildup of particulates, vapors, and gases produced by smoking within the lounge is limited by dilution.

3. By exhausting air outdoors, these contaminants are removed directly from the building.

Ventilation, therefore, plays a dual role in controlling ETS pollution for building occupants, both in the lounge and in other parts of the building.

Lounges Used by Smokers and Nonsmokers

Ideally, separate smoking lounges should be provided for smokers only. Where it is necessary to have lounges which must be used by both smokers and nonsmokers, ventilation can be employed to mitigate ETS exposure.

Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, published by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), prescribes 60 cubic feet per minute (cfm) of exhaust air per person for ventilation of smoking lounges in educational facilities.

Ventilation for lounges used by both smokers and nonsmokers should also be based upon this smoking lounge rate, and multiplied by the **total** anticipated occupancy (one hour or more per week).

Part of the lounge should be identified as the smoking area and air should be directly exhausted above this area. Sectorizing baffles can be installed in supply diffusers, if necessary, to avoid direct flow of supply air to the point of exhaust. Ventilation effectiveness can thereby be maintained and possibly enhanced.

Supply and transfer air, free of ETS, should flow from the nonsmoking area through the smoking area to the point of exhaust. Figure 1 shows such an arrangement and the gradient of contaminant concentration that could be achieved.

Ventilation System

ASHRAE Standard 62-1989, not only prescribes a ventilation rate of 60 cfm of air per person for smoking lounges in educational facilities, it further recommends that such lounges be mechanically exhausted with no recirculation of air.

The ASHRAE Standard currently represents the best consensus of many experts as a basis for ventilation system design. Provisions of the standard for determining the ventilation rates in non-industrial applications, including smoking lounges, will undoubtedly be

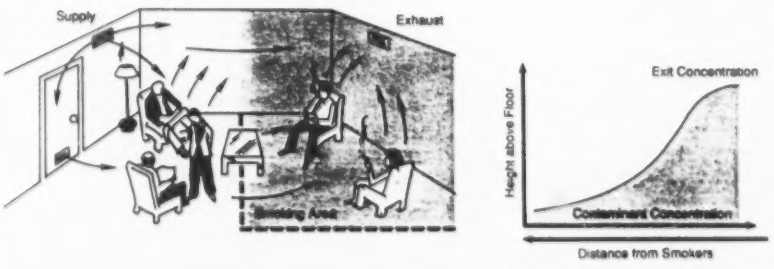

Figure 1. Ventilation and Contaminant Concentration Pattern in Lounge used by Smokers and Nonsmokers

incorporated into model codes and then into state and local building codes. Compliance with its provisions, however, does not assure the elimination of adverse health effects from ETS.

Most mechanical building codes do not currently address smoking lounges. Heavy smoking is the apparent reason for the high rates commonly required for such spaces as bars and cocktail lounges. Fifty cfm per person is required in the most recent editions of the Building Officials and Code Administration (BOCA) Mechanical Code.

Codes such as BOCA, however, permit two thirds of the ventilation air to be recirculated when the particulate content of the air is less than 60 micrograms per cubic meter of air (ug/m^3). This limit may not be attainable in heavy smoking areas in either the room or supply air unless high efficiency air filtration is employed.

Even if the particulate level is achieved, the gaseous components of tobacco smoke would pass through the filters unabated and be recirculated. Accordingly, recirculation of air in such areas is not recommended and may also be disallowed or restricted under code provisions.

The ASHRAE Standard is recommended as the basis for smoking lounge ventilation design applicable to both new and existing schools. The Standard suggests an occupancy rate of 70 persons per 1000 square feet of space.

An estimate should be made, however, of the proportion of school staff who smoke. The number of staff likely to use the lounge may differ from the ASHRAE Occupancy Rate estimate.

If maximum occupancy for an hour or more a week, considering future as well as present use, is anticipated to be different than that determined by the ASHRAE guideline, the total ventilation rate should be based upon the actual, and more realistic, estimate of the number of occupants.

If more reliable data are not available, the ASHRAE Occupancy Rate for the smoking lounge is recommended.

Make-up Air Source

Air exhausted from the lounge must be made up from incoming sources. For the school served by a central air conditioning or ventilating system, the primary make-up source is likely to be the air supply system. If the lounge has been created from an existing lounge or other centrally conditioned (or ventilated) space, the supply air must be properly reapportioned to the newly created lounge and the other spaces served by the common supply system.

If air conditioned, the allocation must be based upon the cooling or heating requirements of each space. It may be necessary to alter ductwork and diffuser locations to properly distribute the reapportioned air quantities to the lounge and the modified spaces adjoining the lounge.

Rebalancing of air flow from existing diffusers is almost always necessary. Refer to the discussion on room air distribution for guidance.

If the cooling and heating load characteristics of a planned lounge are going to differ significantly from that of the remaining space from which it is to be formed, separate temperature control for each may be needed.

In all likelihood the amount of supply air for conditioning will be insufficient to meet the exhaust requirements. Supplemental make up air can be transferred from other spaces through wall or door grilles or ducts from other spaces.

Air from other areas, if free of harmful contaminants, is suitable for transfer to the smoking lounges to replace the air being exhausted. Fire protection regulations in some jurisdictions do not permit transfer of air from a corridor to the lounge through an unprotected opening, such as a door or wall grille. In some cases, it may be necessary to transfer the make-up air through duct work from spaces not used as a means of egress.

Ceiling return air plenums are also an acceptable source, if the reversal of flow from the lounge into the ceiling is avoided. Infiltration into the lounge from adjacent spaces is necessary and will occur if a slight imbalance of exhaust over supply air is maintained.

Make-up air through operable windows is unreliable and an obvious cause for discomfort to occupants of the lounge during extreme weather. Moreover, under certain wind conditions, supply air can exceed the exhaust air, resulting in the movement of air from the lounge into nearby areas.

If the supply air needed for air conditioning exceeds the prescribed exhaust rate, the exhaust rate must be increased to be slightly greater than the supply. A small imbalance of exhaust air over supply air assures that ETS will not flow outward into adjacent occupied areas. A sample calculation of ventilation air flow is presented in Figure 2.

Perimeter spaces in some schools are air conditioned or heated and ventilated by unit ventilators or fan coil units located at the exterior wall. Commonly, a limited amount of outdoor air is mixed within the unit with recirculated air from the space. The blended air is then heated or cooled within the unit.

Unit filters are usually of low efficiency with no potential for significant removal of ETS particles from the recirculated

STEP ONE: Determine the smoking lounge area, amount of supply air and number of smokers

Floor area = 15 ft. x 20 ft. = 300 ft²
Centrally Conditioned Supply Air = 300 cfm (from thermal load calculations)
Average number of staff smokers expected to use the lounge simultaneously = 8

STEP TWO: Estimated occupancy

* By ASHRAE 62-1989

$$\text{Floor area} \times \frac{70 \text{ persons}}{1000 \text{ ft}^2} = \frac{300 \text{ ft}^2 \times 70 \text{ persons}}{1000 \text{ ft}^2} = 21 \text{ persons}$$

* Alternate calculation

Apply a 50% safety factor to the estimated number of staff smokers from Step One

8 persons x 1.5 = 12 persons

*Use Alternate calculation

STEP THREE: Determine the air flow requirements

$$\text{Exhaust air flow} = 12 \text{ persons} \times 60 \frac{\text{cfm}}{\text{person}} = 720 \text{ cfm}$$

Additional makeup air = Exhaust air - Conditioned supply air
= 720 cfm - 300 cfm = 420 cfm

Figure 2. Sample Ventilation Calculations

air. The outdoor air introduced is rarely sufficient to make up and ventilating unit introducing additional outdoor air to equal the deficit.

When an existing space equipped with room units, as described, is subdivided to create a smoking lounge, the provision of heating and air conditioning for both spaces must be engineered to meet the specific circumstances. Additional units or a new separate system may be required for either the new smoking lounge or the remaining space.

Where practical, additional outdoor air to offset any deficit in the amount of available transfer make-up air should be supplied through the new lounge ventilation equipment.

Architectural Considerations

Partitions and ceilings should totally enclose the smoking lounge. Partitions need only extend above the ceiling if necessary to prevent the transfer of smoke-laden air to other spaces.

Doors into smoking lounges preferably should open inward to allow minimum outward flow of ETS when the door is opened. Doors should normally be kept closed and may be fitted with door closers for this purpose.

Other Means of Contaminant Removal

Ventilation is the appropriate method of diluting the products of tobacco smoke and removing them from the building. Other methods, such as electronic air filters, ion generators, and air fresheners are being applied as expedient solutions. These are not recommended as permanent solutions and only occasionally should be employed as temporary ones. Maintenance of these units can be time consuming and involved. Frequently the life cycle costs - including initial, operating, maintenance, and replacement - of these alternative approaches will exceed those of a well designed ventilation system.

The effectiveness of air cleaners depends upon the rate of air being recirculated through them as well as the filtration efficiency. A substantial rate of flow is often required.

Electronic Air Filters

Packaged units equipped with an electronic (electrostatic) filter and fans by which room air is circulated through the filter are employed as "smoke eaters". Some units are supplemented with disposable media prefilters and odor adsorbing cells. Entrained particles are first charged and then attracted to plates oppositely charged as room air is recirculated through the filter.

The particles are held on the plates until the collectors are cleaned or until the agglomerated particles slough off. These larger particles can be captured by an interceptor filter downstream. The interceptors are replaced when loaded.

Collected particles are likely to be tarlike and will stick to the plates rather than slough off. As the plates load up with material, collection efficiency decreases. Therefore, regular maintenance of the filters is necessary, not only to clean the plates and replace media but to ensure that a proper electric charge is maintained.

Electronic filters have been known to produce ozone, another air contaminant. Some manufacturers can furnish certification that the ozone production of their equipment is within permissible levels. It is not known whether degradation of the filters over extended time will increase ozone generation.

Ion Generators

Units of this type are known to reduce smoke haze, but they are not particulate collectors. In theory, particles passing through an electrically charged grid are negatively charged. In the room, other particles are attracted to the ionized particles creating larger ones which will settle out on surfaces of the room or return air ductwork.

Those falling to the floor will be removed in the course of housekeeping. Discoloration from particulate deposits also generally occurs on ceilings, walls, and other surfaces. This can result in a soiled appearance and subsequent outgassing of odorous volatile organic compounds from these surfaces and the interiors of ducts carrying recirculated air. Ion generators also produce ozone.

Air Fresheners

Air fresheners generally are volatile chemicals that vaporize into the room air and dull the sense of smell or, through pleasant odor emissions, mask offensive ones. Fresheners do not remove particles or vapors, but add to the level of airborne chemicals - some with health impairment potential.

Room Air Distribution

The methods of supply and exhaust air distribution within the smoking lounge affect the efficiency of smoke removal. Objects above room temperature heat the air which surrounds them. Examples of such objects include people and even the cigarettes they may be smoking. This heated air will rise, creating an upward convective current called a thermal plume. With conventional air conditioning, the air supply is commonly delivered from overhead diffusers, high wall registers or window units discharging upward. All discharge in a way that is intended to create a circular or cyclonic air circulation.

The intention is to get good mixing for thermal effectiveness and dilution of contami-

ness and dilution of contaminants generated within the space. In the smoking lounge the predominant source of contaminants is people: releasing the products of smoking as well as those of human physiological processes. Many of these contaminants would drift upward in the thermal plumes, but these gentle currents are overridden by the mechanically driven room air circulation.

If supply air is delivered low in the room at low velocity and exhausted high, the air pattern can work with the buoyancy of the thermal plume to enhance the effectiveness of contaminant removal.

Air supplied near the floor at temperatures much below room temperatures can cause uncomfortable drafts. Such an arrangement for the air conditioning supply is best left to design engineers familiar with the technique.

Transfer air, however, at or near room temperature should be introduced near the floor, preferably at sufficient velocity or at appropriate locations to bring such air into the vicinity of the occupants. Exhaust outlets should be high in the room.

The conditioned air supply outlets, if located in the ceiling, or high on the wall, should be arranged to avoid interfering with the upward flow of room air. Supply air must not be directed toward the point of exhaust, otherwise the flow of clean air will bypass the occupants. There should be no return air outlet in the smoking lounge.

Existing return air registers in newly created lounges should be closed or removed. Such closures may require rebalancing of return air registers in other spaces connected to the system to avoid creating negative pressure due to an excess of return air.

Figure 3 typifies conventional overhead air supply and exhaust arrangements and graphs the anticipated contaminant concentration versus the distance from the floor.

Other Design Considerations

The lounge may be exhausted by a separate fan system conveying the air through connecting duct work to the outdoors or by connection with a toilet exhaust system. If used for this purpose, the capacity of an existing toilet exhaust system must be increased and the air distribution rebalanced to achieve proper air flow rates.

Exhaust fans should be located accessibly for maintenance and selected for a level of quietness appropriate for "office space" as further defined by Noise Criteria Curve 35 described in the ASHRAE HVAC Handbook. Fan systems should be equipped with back draft dampers to prevent reversal of flow.

Energy Considerations

When the lounge is unoccupied there is little reason for exhaust ventilation. The control of its exhaust fan should consider the cause of energy conservation. The appropriate control must relate to specifics of the application. Possible options include:

- manual operation of the exhaust fan controlled from the light switch (preferably with a time delay device to operate the fan for some time after the lights have been switched off)
- manual control from a building supervisory center

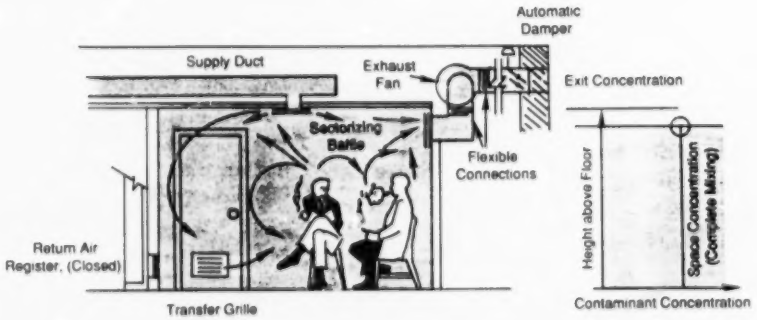

Figure 3. Smoking Lounge Ventilation and Contaminant Concentration Pattern

- timer control
- delegated manual control by local on/off switch.

When the building is unoccupied and the air supply system turned off, the lounge exhaust should be deactivated by interlock.

Exhausting air from the smoking lounge will have some impact upon the school energy systems. Additional outdoor air will be needed for make-up. It will require cooling in warm weather and could require additional heating in cold weather. Operating the exhaust fan will also draw additional electric power. Generally, the effect on building system capacities is usually inconsequential.

Maintenance Considerations

Exhaust ventilation systems will not usually involve undue maintenance efforts. A periodic performance check of exhaust fans and dampers is in order. At least once a year, the lounges where smoking is permitted should be checked to verify that they are under negative pressure. Holding a strip of tissue at the transfer grille face is often a convenient technique.

Many school systems have capabilities for quantitative measurement of air flow. As part of a scheduled maintenance program, smoking lounge exhaust and supply air flow should be checked along with critical ventilation in other spaces.

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